9700 S. Cass Avenue · Argonne, IL 60439 · neinfo@anl.gov

Nuclear Engineering Division

Major Programs

- **Advanced Fuel Cycle Initiative:** Development and assessment of technologies for improved management of spent nuclear fuel.
- **Generation IV Nuclear Energy Program:** Development of next generation nuclear systems featuring significant advances in sustainability, economics, safety, reliability, proliferation resistance and physical protection.
- **Hydrogen Initiative:** Assessment and development of nuclear technologies for the generation of hydrogen as a replacement for fossil fuels.
- **Reduced Enrichment for Research and Test Reactors (RERTR):** Conversion of research reactors from high- to low-enriched uranium fuel to reduce risk of nuclear weapons proliferation.
- **International Nuclear Safety:** Fostering open exchange of safety information and improvements of nuclear plant safety worldwide.
- **Materials Disposition:** Safe disposition of excess weapons plutonium through reactor irradiation and conversion to spent fuel.
- **Decontamination and Decommissioning:** Development, demonstration and deployment of technologies for safe and economical D&D of nuclear facilities.
- **National Security and Nonproliferation:** Limiting risk of nuclear weapons proliferation through export control policy support, safeguarding of special nuclear materials in the Former Soviet Union, development of information management systems.
- **Nuclear Criticality Safety:** Enhancing capability for assuring safe storage and transport for nuclear materials.
- **Nuclear Waste Form Modeling:** Assuring safe performance of waste forms from processed EBR-II spent fuel in the Yucca Mountain Geologic Repository.

Facilities

- **Advanced Simulation and Control Laboratory:** contains state-of-the-art electronic equipment for conducting collaborative research on applications of computing, communication and visualization technologies.
- **Aerosol Laboratory:** houses equipment to measure and record the physical parameters necessary to characterize the formation and transport of aerosols.
- **Computer Facilities:** state-of-the-art equipment provided to in-house staff and collaborating scientists. We have a Beowulf cluster (2 control nodes and 78 computer nodes) as an advanced computational platform for performing a variety of engineering analyses. We also use facilities outside the Division such as Jazz, a terascale (10E12 calculations per second) Linux computing cluster with 350 nodes, and the CAVE, one of the four sophisticated automatic virtual environment systems in existence.
- **Engineering Development Laboratory**: facilities used to obtain information on the behavior of molten nuclear fuel, both in-reactor pressure vessel and ex-vessel.
- **In-Reactor Experiments:** performance of accident simulation experiments on nuclear reactor fuels and materials in the TREAT facility at Idaho National Laboratory.
- **Irradiated Materials Laboratory:** used to conduct research on the behavior of commercial nuclear reactor materials, including fuel, pressure vessels, and other in-reactor components. The four beta-gamma hot cells and the glove boxes are used to determine mechanical properties of these materials and degradation due to long-time operation in corrosive and irradiation environments. Loss-of-coolant accident environment is also simulated to allow determination of post.
- **Laser Applications Laboratory:** houses two high-power laser systems, complete with diagnostics for materials-processing functions – a 6 kW CO_2 laser and a 1.6 kW pulsed Nd:YAG laser.
- **Non-Destructive Evaluation (NDE) and Testing Facilities:** contains state-of-the-art NDE laboratories including microwave/millimeter wave, acoustic/ultrasonic, X-ray, thermal imaging, optics, and eddy current for health monitoring of materials and components used in aerospace, defense, and power generation (fossil and nuclear) industries as well as for medical and scientific research.
- **Prototype Cathode Processor:** high-temperature vacuum furnace capable of retorting volatile components of the charge material and producing a consolidated ingot (used primarily for research on spent nuclear fuel processing).
- **Robotics Laboratory:** houses various remote manipulator systems, including the Dual Arm Work Platform, to support enhancements to teleoperation of remote systems for nuclear applications.
- **Sodium Reaction Experimental Test Facility:** fully instrumented facility for conducting and observing reaction experiments between moist gases, steam and alkali metals.

Nuclear Engineering Division

Argonne National Laboratory
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Overview

Nuclear Engineering (NE) is one of the divisions within the Applied Science and Technology directorate of Argonne National Laboratory. The Division and its precursors have contributed to the development of civilian nuclear power systems for over 50 years, ever since the dawn of the nuclear age. Over the years, we have significantly expanded our competencies and applied them to problems outside of the civilian nuclear arena.

Our mission is to (1) advance the design and operation of nuclear energy systems, and (2) apply our nuclear energy–related expertise to current and emerging programs of national and international significance. We conduct analytical and experimental research with concentration in advanced nuclear energy systems, nonproliferation and national security, and environmental management. Our extensive capabilities in modeling and simulation are applied in the development of diverse engineering systems and the optimization of their performance.

The NE Division's programs are supported primarily by the U.S. Department of Energy through a number of its offices. Other sponsors from a broad range of U.S. Government and industry organizations also support work in the Division. We actively seek opportunities to collaborate with university, national laboratory, industry, and international partners in pursuit of their interests and our mission goals.

Dr. Hussein S. Khalil
Director
Nuclear Engineering Division

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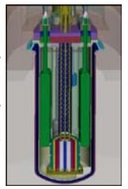
For more information, please visit our website at www.ne.anl.gov
or email us at NEinfo@anl.gov

NE MAJOR CAPABILITIES

Nuclear Systems Modeling and Design Analysis

- Reactor Physics and Fuel Cycle Analysis
  We have played a major role in the design and analysis of most existing and past reactor types and of many advanced reactors, particularly those cooled by liquid metal. Our researchers have concentrated on developing computer codes for the assessment of reactor performance and safety characteristics, validating computer models by using experimental information obtained at critical facilities and power reactors, and applying these models in analyses that support core design and fuel cycle optimization.
- Nuclear Plant Dynamics and Safety
  We perform analyses using large-scale, integrated computer codes which model the entire reactor plant. The product is a transient simulation of the behavior of all the major components in the plant, including fuel and coolant, coolant systems and associated components, and plant control and protection systems.
- Advanced Reactor Development
  We are the leading U.S. National Laboratory for the development of technologies for advanced nuclear power systems. This capability includes expertise in essentially all the major disciplines required in reactor design and development and the project management capability to integrate these disciplines efficiently and effectively.



- Nuclear Waste Form and Repository Performance Modeling
  We develop and apply computer software to address long-term performance of waste forms resulting from electrometallurgical processing of spent nuclear fuel. We are also proficient at developing and using models to assess and predict repository performance with a number of other waste forms and under other impact parameters.

Nuclear Systems Technologies

- Nuclear Criticality Safety
  We perform criticality safety and shielding evaluations for nuclear facilities with complex configurations and operations involving wide ranges of geometries, materials, and neutron spectra. These capabilities are based on a staff with decades of cumulative experience (experimental and analytical) and the latest software and nuclear data libraries.

- Research Reactor Analysis
  We provide the analytical and design evaluations needed by the RERTR program. Our computational database, which is continuously updated and improved, consists of a number of computer codes to analyze the physics, thermal-hydraulics, and safety performance of research reactors. Using these analytical tools, the RERTR program performs studies of specific foreign and domestic reactors to assess their potential for conversion to LEU fuel and to provide analytical support for such conversions.
- Systems/Process Monitoring, Diagnostics and Control
  We develop, demonstrate and apply advanced software tools for optimizing the operation of nuclear power plants and other engineering systems. This software generates and substantiates information online about the condition of plant systems. This information can then be used to maximize plant availability and power output, optimize plant maintenance functions, and help operators cope with potential upsets.

Nuclear Systems Technologies (continued)

- Decontamination and Decommissioning (D&D)
  We perform decontamination and decommissioning of research reactors and surplus contaminated facilities, develop technology to enhance D&D safety and efficiency, and share our expertise with the international community through project management and technical oversight, training and technical exchanges.

Risk and Safety Assessments

- Risk Methodology and Evaluation
  We conduct both deterministic and probabilistic safety analyses. This field covers a wide range of disciplines, usually requiring expertise in a number of areas as well as familiarity with formal hazards and risk evaluation methods. With many engineering disciplines represented on our staff, we are highly qualified to conduct the type of in-depth hazards and risk evaluations that are necessary for modern facilities to compete in today's highly regulated environment.
- Facility Safety Assessments
  Operations support for nuclear facilities within Argonne and throughout the DOE Laboratory system is provided in the form of detailed vulnerability assessments required under emerging national security-related regulations. We also undertake facility safety analysis report preparation and upgrade, and preparation for safety documentation to support facility modifications or special projects.

National Security & Non-Proliferation Technologies

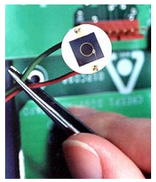
- Nuclear Export Controls
  We provide technical advisory services to DOE in the implementation of U.S. nonproliferation policy. This includes assessments of proliferation risks presented by emerging technologies and by proposed transfers of materials, equipment, and technology, and participation in DOE programs designed to mitigate these risks.

- Information Technology and Security
  We are developing a three part tracking system for DOE to assess and monitor foreign ownership, control or influence (FOCI) of contracting companies with access to special nuclear material, classified information, or other sensitive technologies. FOCI includes a web site for contractors, processing tools for DOE to render specific FOCI determinations, and tools for the production of security, counter-terrorist and counter-proliferation analyses.
- Research Reactor Conversions
  We develop the technologies needed to use of low-enriched uranium (LEU, <20%) instead of high-enriched uranium (HEU, ≥20%) in research and test reactors, and to do so without significant penalties in experiment performance, economic, or safety aspects of the reactors. Research and test reactors utilize nearly all the HEU used in civil nuclear programs, and worldwide attainment of the RERTR objectives will support important U.S. nonproliferation goals.

National Security & Non-Proliferation Technologies (continued)

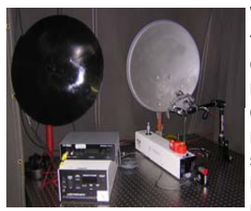
- International Nuclear Safety
  We support DOE efforts to improve international nuclear safety. We work to build capabilities within countries, especially those with Soviet-designed reactors, to determine the safety status and assess the risks of their nuclear power stations. These capabilities and the results of comprehensive deterministic and probabilistic safety assessments have led to dramatic improvements in the safety of these operating reactors. Through our efforts on behalf of DOE, many projects have led to gainful employment for former Soviet weapons scientists, reducing nuclear proliferation risks.

- Non-Intrusive Detection Technologies
  We develop and evaluate technologies for the interdiction of nuclear materials, explosives, narcotics, and other illicit substances based on nuclear techniques. We pursue research on passive radiation detection and active interrogation techniques for the localization, identification, examination, and characterization of special nuclear materials, nuclear fuel, spent nuclear fuel, and nuclear waste. We also develop systems and equipment based on these techniques. These projects are supported by basic work in radiation detector development, nuclear data, and applied radiation physics.



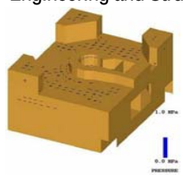
- Non-Destructive Evaluation (NDE) Technologies
  We develop and provide technologies for interrogation and characterization of materials, components, and systems using state-of-the-art and emerging NDE techniques. Our capabilities have been applied to the aerospace, defense, and power generation (fossil and nuclear) industries to assess the integrity of critical components and thus help reduce system failures that can lead to costly shutdowns, cause damage to expensive equipment, and jeopardize the safety of end users. Our specialized NDE technologies have also been used in applications pertaining to scientific and medical research.

- Sensors & Instrumentation Technologies
  We develop and evaluate sensor technologies for industrial process control, biomedical applications and remote detection of trace gases, toxic chemicals, explosives, and nuclear materials. Techniques applied to our sensor development include acoustic/ultrasonic, ion optics and electromagnetic waves ranging from millimeter waves (mmW) to gamma rays. Specific accomplishments in recent years include (a) THz spectroscopic technique for remote detection of explosives, (b) mmW imaging system for detecting concealed objects, (c) photoacoustic technique for remote sensing of explosives and toxic chemicals, (d) non-intrusive online ultrasonic viscometer, (e) speed-of-sound helium/hydrogen leak detector, and (f) spark-discharge ion-mobility NOx sensor. We also pursue research on both passive and active techniques to detect and interrogate nuclear materials. All projects support DOE missions in energy and environmental research and DHS in safeguard and protection of our nation.

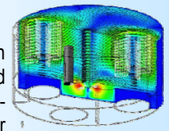


Engineering Computation and Design

- Engineering and Structural Mechanics
  We develop computer codes and analytical methods for modeling the response of structures and continua to external loadings in two- and three-dimensions. Our codes are specialized for solving nonlinear static, transient dynamic and thermal problems for structures, solids, fluids, and fluid-structure interactions.



- Systems/Component Design, Engineering and Drafting
  We provide a wide variety of equipment engineering, project engineering, design engineering and drafting services to Laboratory and outside researchers. The capabilities span a broad area, from project management to research and detailed design of systems and components, and have been applied in such diverse areas as vacuum and cryogenic systems, manufacturing engineering, hot cell equipment, and spent fuel processing systems.
- Heat Transfer and Fluid Mechanics
  We specialize in the development and application of advanced computational methods for fluid and heat engineering. Simulation techniques are applied to provide fluid dynamics and heat transfer solutions supporting numerous nuclear and non-nuclear initiatives.



Engineering Experimentation

- Reactor Safety Experimentation
  We conduct a wide range of experimental research related to the safety of existing and future reactor technologies. This includes state-of-the-art experiments investigating high-temperature nuclear fuel melt behavior and materials interactions. We possess unique facilities that can accommodate the special needs of reactor materials testing.

- Aerosol Experiments
  We have extensive analytic and experimental capabilities to characterize the formation and transport of aerosols formed from the condensation of vapors. Computer codes have been developed to analyze various phenomena related to homogeneous and heterogeneous nucleation, aerosol agglomeration, and aerosol deposition.
- Systems/Component Testing
  We research, develop, design, procure, manufacture, install and test components and systems required for unique application. This includes the development of first-of-a-kind large-scale systems and components with complex requirements such as corrosive/hazardous materials, high-temperature structural integrity, and remote handling.

- Laser and Robotics Applications
  We carry out research and development on laser-based applications for materials processing, oil extraction technological enhancements, and aerosol or spray characterization. Computer simulation and robot task programming tools are employed to enhance the safety and efficiency of telerobotics in the decontamination and decommissioning of nuclear power plants, space nuclear power systems, and other remote applications.